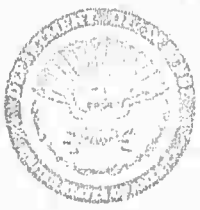
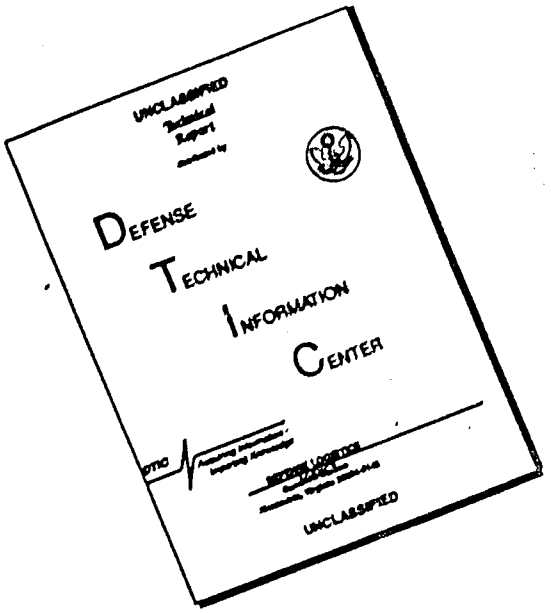
AD NUMBER
AD309888
CLASSIFICATION CHANGES
TO: **UNCLASSIFIED**
FROM: **CONFIDENTIAL**
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; AUG 1959. Other requests shall be referred to Army Armament Research and Development, Aberdeen Proving Ground, MD.**
AUTHORITY
ARRADCOM ltr 26 Dec 1979; ARRADCOM ltr 26 Dec 1979



"NOTICE: When Government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the U.S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto."

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

CONFIDENTIAL

Development and Proof Services

Report No. DPS/TS4-4218/8

ARTILLERY DIVISION

REPORT ON

TEST OF SHELL HEP, T294E3 FOR 90-MM RIFLE T149 (U)

Eighth Report On Ordnance Project No. TS4-4218

(D. A. Project No. 5A04-03-057)

LEWIS R. LaBUWI

AUGUST 1959

Aberdeen Proving Ground
Maryland

CONFIDENTIAL

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

AUTHORITY: ORDBA, FA-TPR-1620-501 LRIaBuwi/ch

TEST OF SHELL, HEP, T294E3 FOR 90-MM RIFIE, T149 (U)

Eighth Report On Ordnance Project No. TS4-4218

Dates of Test: 5 and 6 May 1959

ABSTRACT (C)

This report covers the firing of 15 T294E3, HEP projectiles to determine their armor-plate-defeating capabilities. Firings were conducted at both 70°F and -40°F, against 3-inch armor plate positioned at 0° and 60° obliquity. The results indicated that the round was capable of defeating the 3-inch armor plate when the ammunition was temperature-conditioned at 70°F, and was not capable of defeating the 3-inch armor plate when ammunition was temperature-conditioned at -40°F. It is recommended that a shell of this design be tested in the T219E4 rifle to determine the cause or causes of failures at low temperatures. If the round can be made to function at low temperatures, it is further recommended that an investigation be made to determine striking velocity limitations, spall velocity, and the upper thickness of armor plate the round is capable of defeating.

CONFIDENTIAL

CONTENTS

(The Annex is on file in the Technical Library, APG, for reference purposes. Copies of the Annex may be furnished to recipients of this report upon request.)

1. (C) INTRODUCTION

The purpose of this test was to determine the armor-plate-defeating capabilities of the T294E3 projectile. This projectile differed from most HEP projectiles in that it was launched with virtually no spin, had a spike ogive and fins for stabilization, and was loaded with Octol. The round was fired in the T149 rifle, which was never standardized and is obsolete; however, the data obtained are applicable to HEP projectiles of this type for other weapons.

2. (C) DESCRIPTION OF MATERIEL

The T294E3, HEP projectile is approximately 14 inches long and weighs approximately 7 lb. It has an aluminum spike ogive, an aluminum fin assembly, and a thin-walled, steel body. It contains approximately 3.3 lb of Octol filler (when the T199 fuze is used) which is detonated by a fuze located at the base of the explosive charge. Each of the 15 projectiles fired in this test were received with T199 dummy fuzes. As requested by Mr. Yannuzzi of Frankford Arsenal, the dummy T199 fuzes were replaced by T278E7 fuzes. It was necessary to add approximately 0.04 lb of Octol to each projectile because the T278E7 fuze is approximately $\frac{1}{2}$ inch shorter than the T199 fuze. Only the graze-functioning feature of the T278E7 fuze was operative since the "Lucky" crystal was omitted intentionally.

3. (C) DETAILS OF TEST

3.1 Procedure

Since a complete round utilizing the T294E3 projectile had never been developed, it was necessary to improvise an ignition cartridge consisting of a paper tube 7 $\frac{1}{2}$ inches long and 3/4 inch in diameter, filled with 500 grains of grade A1 black powder. The paper used was approximately 0.005 inch thick. The tube was a single thickness with an overlapping seam of approximately 1/4 inch width along its length. The open end of this tube fitted over a boss on the inside of the base of the cartridge case. The end of the tube toward the projectile was sealed with a disk of onionskin paper and a thin ring of cork. The tube was positioned in the center of the propelling charge. The propellant was contained by a paper liner in a steel, T83E2 cartridge case. The base of the cartridge case contained two percussion primers 180 degrees apart. A train of 49 grain of FFFG black powder joined both primers and the ignition cartridge. The FFFG black powder was retained in the boss of the cartridge case by a glued-on cap of onionskin paper.

Two T18 internal copper-crusher pressure gages were placed in the base of each cartridge case after the projectile was assembled into a complete round.

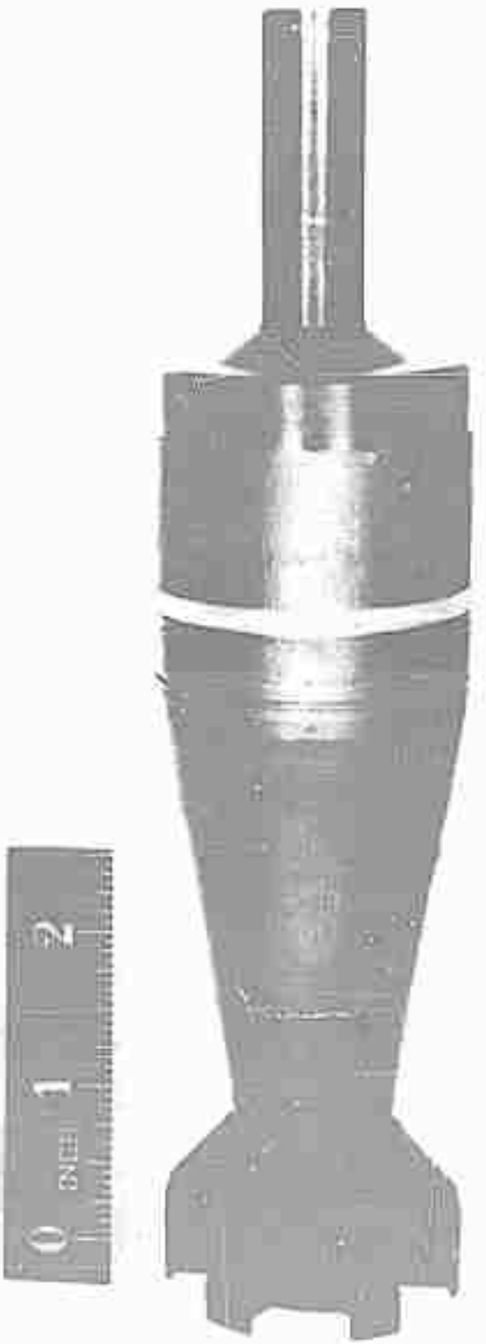


Figure 1: Shell, HEP, 90-mm, T294E3.

The 15 projectiles were fired against a 3-inch-thick homogeneous armor plate placed 100 feet from the muzzle of the rifle. Ten rounds were temperature conditioned at /70°F and fired with the armor plate positioned at either 0° or 60° obliquity. The remaining five rounds were temperature-conditioned at -40°F and fired with the armor plate positioned at 0° obliquity. Two 16-mm, Fastax, motion-picture cameras were positioned in such a manner that one camera photographed the projectile as it approached and impacted on the face of the armor plate, while the other camera recorded the spalls that were driven off the rear. For measuring the velocity of the spalls a breakwire screen was affixed on the rear of the armor plate. As the spalls were driven off the armor plate they passed through the breakwire screen and started a timing light which was recorded by the camera. The camera also recorded the spalls as they impacted on a vertical target behind the vertical plate or a horizontal target behind the 60° plate. The exact distance from the spalled area to the place on the target where the spall impacted was measured for each round, and used in computing spall velocities. The distance was approximately nineteen feet for the vertical plate and approximately five feet for the 60° plate.

3.2 Results

Three of five projectiles produced complete spalls when fired against 0° plate and temperature-conditioned at /70°F. Of the other two, one projectile produced a hinged spall approximately 80 per cent detached, and one failed to bulge or spall the plate.

Four of five projectiles produced complete spalls when fired against 60° plate and temperature-conditioned at /70°F. One projectile failed to produce a bulge or spall under these conditions. Four of five projectiles fired against 60° plate and temperature-conditioned at -40°F failed to bulge or spall the armor plate. One projectile (test round number 3) had such a low velocity that it travelled for a distance of only approximately thirty feet from the muzzle and failed to reach the plate. Apparently the cause of this malfunction was poor ignition.

Table I is a summary of the results obtained from these firings.

Table I. Summary of Results

Obliquity of armor plate: 0°

Temperature of ammunition: /70°F

Test Round No.	Muzzle Vel, fps	Pressure, psi	Spall Velocity, fps [a]	Duration of Spalling, ms [b]
6	1282	4100	No Spall	--
7	1056	4350	No Spall	--
8	756	2150	1185	18
9	1065	5300	1045	22
10	1065	4350	815	27

Obliquity of armor plate: 60°

Temperature of ammunition: +70°F

Test Round No.	Muzzle Vel, fps	Pressure, psi	Spall Velocity, fps [a]	Duration of Spalling, ms [b]
11	1063	4450	740	13
12	859	2400	Lost	12
13	893	3450	No Spall	--
14	1059	4300	705	14
15	1059	4200	670	13

Obliquity of armor plate: 60°

Temperature of ammunition: -40°F

1	803	2000	No Spall	--
2	915	3000	No Spall	--
3	Lost	A	B	--
4	931	3300	No Spall	--
5	920	3250	No Spall	--

A - Too low to measure

B - Missed plate

[a]Values represent average values of velocity over the total flight interval from initiation to point of impact.

[b]These values represent the total time that the spalls, either major or minor, were in flight between the target and impact area.

3.3 Discussion

The improvised ignition system was not satisfactory from the standpoint of velocity uniformity and functioning at low temperatures.

The T278E7 fuze, Lot DOFL-197-3, has functioned satisfactorily (with Lucky initiation) at -40°F, in the HEAT shell. It is not known what effect low temperatures have on this fuze when only the graze-functioning feature is operative.

It is theorized that the distribution of the Octol filler on impact, at the time of fuze initiation, may change with temperature conditions, and may be the cause of failure at low temperatures.

4. (C) CONCLUSIONS

It is concluded that a projectile of this type (i.e., nonrotated, spike-ogived, and Octol-loaded) is capable of defeating armor plate by spalling when the projectile is temperature-conditioned to 70°F. The armor-defeating capabilities of the round at low temperatures is in doubt.

5. (C) RECOMMENDATIONS

It is recommended that:

a. A shell of this design be tested in the T219E4 rifle, to determine the cause or causes of failure to defeat armor plate at low temperatures. Tests should be conducted at various temperatures, including high temperatures, and fuze functioning time should be measured to determine if these are factors causing failure.

b. If the round can be made to function at low temperatures, an investigation be conducted to determine striking velocity limitations, spall velocity, and the upper thickness of armor plate the round is capable of defeating.

SUBMITTED:

Lewis R. LaBuwi

LEWIS R. LABUWI
Test Director

REVIEWED:

G. Morrow

G. MORROW
Chief, Mortar & Recoilless
Rifle Branch

H. A. Bechtol

H. A. BECHTOL
Chief, Artillery
Division

APPROVED:

for H. A. Noble

H. A. NOBLE
Assistant Deputy Director
for Engineering Testing
Development and Proof Services

APPENDICES

APPENDIX A

Correspondence

ORDNANCE CORPS

FRANKFORD ARSENAL

PHILADELPHIA 37,

PENNSYLVANIA

Mr. A. R. Yannuzzi/do/5219

IN REPLY

REFER TO ORDBA-1620

2 March 1959

SUBJECT: Cartridge, HEP, 90mm T294E3D

TO: Commanding General
U. S. Army Ordnance Proving Ground, Aberdeen
Aberdeen, Maryland

1. Inclosed is FA-TPR-1620-501 outlining a program for the evaluation of the 90mm T294E3D HEP Round. Funds for this test have been forwarded to Aberdeen Proving Ground under AIF Order No. 87170100-99-35070-52.

2. It is requested that this Arsenal be notified in advance of the firing of these tests in order that a representative may be present if so desired.

FOR THE COMMANDER:

Guy M. Lubold Jr.

1 Incl
a/s (in dupe)

GUY M. LUBOLD, JR.
Captain, Ord Corps
Assistant

1. Material for Test

Item	Quantity	Design	Dwg. No.	Remarks
1	15	90mm T294E3D	Chamberlain Corp J7577-848	Octol Loaded

2. Project Authority

TS4-4018

3. Arsenal Expenditure Order Number

Funds have been transferred to Aberdeen Proving Ground under AIF Order No. 87170100-99-35070-52.

4. Object of Development

To develop an optimum fin stabilized multi-purpose round for the 90mm T219 Rifle.

5. History Sketch

There have been no previous Component Development Tests of this round at Aberdeen Proving Ground. The 90mm T294E3D is a spike nosed HEP round that was designed for the 90mm T149 Recoilless Rifle. This round has not been dynamically tested. It is felt that by conducting the test, valuable data will be obtained that can be directly applied to the 90mm and 120mm multi-purpose development.

6. Description in Detail of Improvements Made Since the Last Proving Ground Test

There have been no previous tests of this round.

7. Local Tests

None

8. Object of Test

To determine the armor defeating capability of this round.

9. Precautions in Handling and Testing

Normal precautions in handling live ammunition will be exercised.

10. Recommended Test Program

a. Fire five (5) rounds at a temperature of $\not{-}70^{\circ}F$ against 0° plate.

b. Fire five (5) rounds at $\not{-}70^{\circ}F$ against 60° plate.

c. Fire five (5) rounds at $-40^{\circ}F$. The angle of the plate is to be determined upon completion of parts a. and b.

d. High speed movies are to be taken at the front and back of the plate during impact and function.

The proper thickness of plate to be used for a., b., and c. will be determined during the test, the thickness being reduced until defeat of the plate was obtained.

11. Remarks

All material required for this test is available at Aberdeen Proving Ground.

The above Test Program has been prepared in accordance with recommendation submitted by Aberdeen Proving Ground. The Test Program can be changed at the discretion of the proof director in order to obtain the desired results.

APPENDIX B

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND, MARYLAND
FIRING RECORD

To determine the armor plate defeating capabilities of Projectile, HEP, T294E3 (U)

Firing Record No.: P-64424
Dates of Test: 5 and 6 May 59
Authority: FA-TPR-1620-51

Development Test — W. O. No. 331-917-01 — gl

MATERIEL (U)

Rifle, 90-mm, Serial No. 7. Mount, Frankford Arsenal Accuracy Rest.

AMMUNITION (U)

Projectile: Shell HEP, T294E3, Octol-Loaded, Lot - PA-E-22942.
Fuze: PI, BD, T278E7, Lot DOFL-197 (Tube Rd Nos. 199 to 208), Lot DOFL-197-3 modified for low temperature firing (Tube Rd Nos. 209-213).
Case, Cartridge: Steel, T83E2, with paper liner. 49 grains FFFG black powder in the base assembly of the cartridge case.
Ignition Cartridge: 500 grains Grade A1 black powder loaded in paper tube, wrapped 1-1/2 turns, 0.005 inch thick, 7-1/2 inches long, 3/4-inch in diameter.
Propellant: M10, MP, 0.024-inch web, Lot PA-E-5616-51, charge weight 35.25 oz.

FACILITIES (C)

Firing Position: Ford's Farm.
Armor Plate: 6-by 6-feet by 3-inch homogeneous armor plate, Number 19954-3-1.
Brinell Hardness: 286.
Charpy Value: 48 ft-lbs, at -40°F.

INSTRUMENTATION (U)

Velocity: Two 30-inch-diameter, 280-turn, wire-wound induction coils connected to two counter chronographs.

Chamber Pressure: Two T18 internal copper crusher pressure gages, placed in the base of each cartridge case. Copper Lot 2AR-54.

Photography: Two 16-mm Fastax Motion-picture cameras, one used to photograph the round approaching and impacting on the face of the armor plate, and the other photographing the spalls coming off the rear of the plate.

ROUND-BY-ROUND DATA (C)

Round No. Tube	Round No. Test	Shell Wt, lb	Muzzle Vel, fps	Press., psi/100	Spall Velocity, fps	Duration of Spalling, ms	Dimensions, inches of Facial Impression	Dimensions, inches of Rear Bulges or Spalls	Remarks
					Obliquity of Armor Plate: 0° Temperature of Ammunition: ≠ 70°F 5 May 1959				
199	6	7.25	1282	41	-	-	5x5x1/4	4-1/2x5x1/4	Hinged spall 80% detached.
200	7	7.21	1056	43	-	-	-	-	Failed to bulge or spall.
201	8	7.16	756	21	1185	18	6-1/2x6-1/2x1/2	7-1/2x7x3/4	Spall.
202	9	7.22	1065	53	1045	22	7x7x1/4	7-1/4x8-3/4x3/4	Spall.
203	10	7.21	1065	43	815	27	8x7-1/2x5/8	7x7x5/8	Spall.
					Obliquity of Armor Plate: 60° Temperature of Ammunition: ≠ 70°F 6 May 1959				
204	11	7.27	1063	44	740	13	7-1/4x6x1/2	5x7x1-1/2	Spall.
205	12	7.30	859	24	Lost	12	7x5-3/4x7/16	5x4-1/4x1-1/4	Spall.
206	13	7.25	893	34	-	-	-	-	Failed to bulge or spall.
207	14	7.18	1059	43	705	14	7x5-3/4x1/2	6x5-3/4x1-3/4	Spall.
208	15	7.25	1059	42	670	13	6x5-3/4x1/2	7-1/2x5-1/2x1-1/2	Spall.
					Obliquity of Armor Plate: 60° Temperature of Ammunition: -40°F 6 May 1959				
209	1	7.25	803	20	-	-	6x5x1/4	-	Failed to bulge or spall.
210	2	7.29	915	30	-	-	8-1/2x5x1/4	-	Failed to bulge or spall.
211	3	7.25	-	-	-	-	-	-	-
212	4	7.23	931	33	-	-	5x4x1/4	-	Failed to bulge or spall.
213	5	7.27	920	32	-		7x5-1/2x1/4	-	Failed to bulge or spall.

One round (test round number 3) had such a low velocity that it traveled for only a distance of approximately thirty feet from the muzzle. Apparently the cause of the malfunction was poor ignition.

CONFIDENTIAL

This firing record forms a part of the Fourth Report on Project TB5-4018.

SUBMITTED:

LEWIS R. LABUWI
Test Director

REVIEWED:

G. MORROW
Chief, Motar &
Recoilless Rifle Branch

APPROVED:

H. A. BECHTOL
Chief, Artillery Division

APPENDIX C

Analytical Laboratory Report 59-AL-87
ANALYTICAL LABORATORY REPORT 59-AL-87
10 June 1959

Test Title: Test of Cartridge, HEP, T294E3

Project No.: FA-I/59/18

Prepared for: Mortar and Recoilless Rifle Branch, Artillery Division

---

Firings were conducted on 5, 6 May 1959 of fifteen instrumented rounds to determine spall velocity. These rounds were fired at a plate target positioned either at 0° or 60° obliquity. The first ten rounds were conditioned to a temperature of 70° Fahrenheit and the remaining five were conditioned to -40° Fahrenheit before firing.

One 16-mm Fastax camera photographed the round striking the target and the flight of the spalls that were driven off. This record of spall flight was used to determine the velocity of the major spall.

Time was recorded on the film records at millisecond intervals. The start of time was established by the activation of a 50-51 sequential coder initiated by the spall leaving the target.

Results are given in the following table.

Rd. No.	Target Obliquity (degrees)	Spall Velocity* (fps)	Duration of Spalls** (ms)	Rd. No.	Target Obliquity (degrees)	Spall Velocity* (fps)	Duration of Spalls** (ms)
6	0	No spall	-	14	60	705	14
7	0	No spall	-	15	60	670	13
8	0	1185	18	1	60	No spall	-
9	0	1045	22	2	60	No spall	-
10	0	815	27	3	60	No spall	-
11	60	740	13	4	60	No spall	-
12	60	Lost	12	5	60	No spall	-
13	60	No spall	-				

* Values represent average values of velocity over the total flight interval from initiation to point of impact.

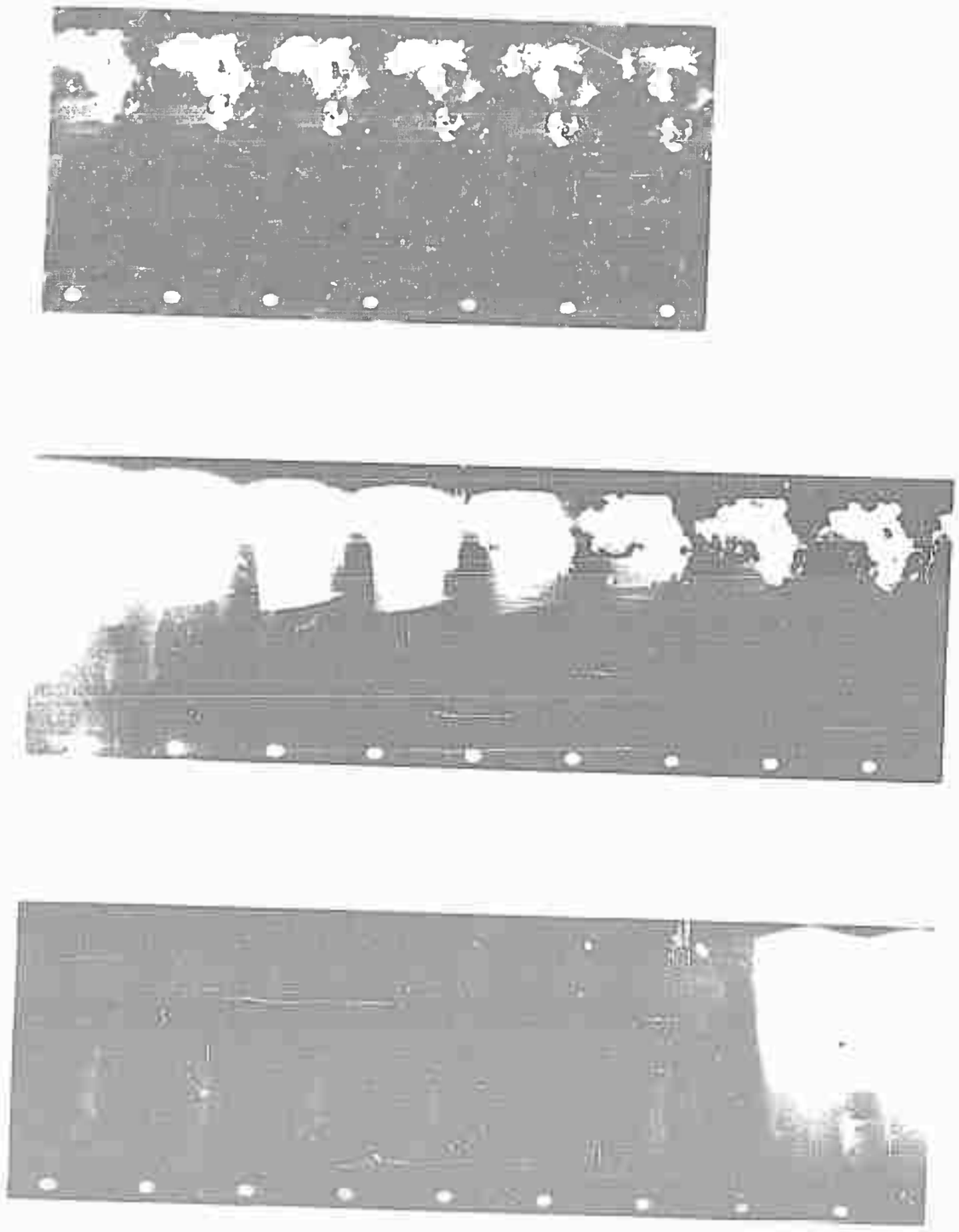
** These values represent the total time that spalls, either major or minor, were in flight between target and impact area.

SUBMITTED:
W. D. Garnier
W. D. GARNIER
Mathematician

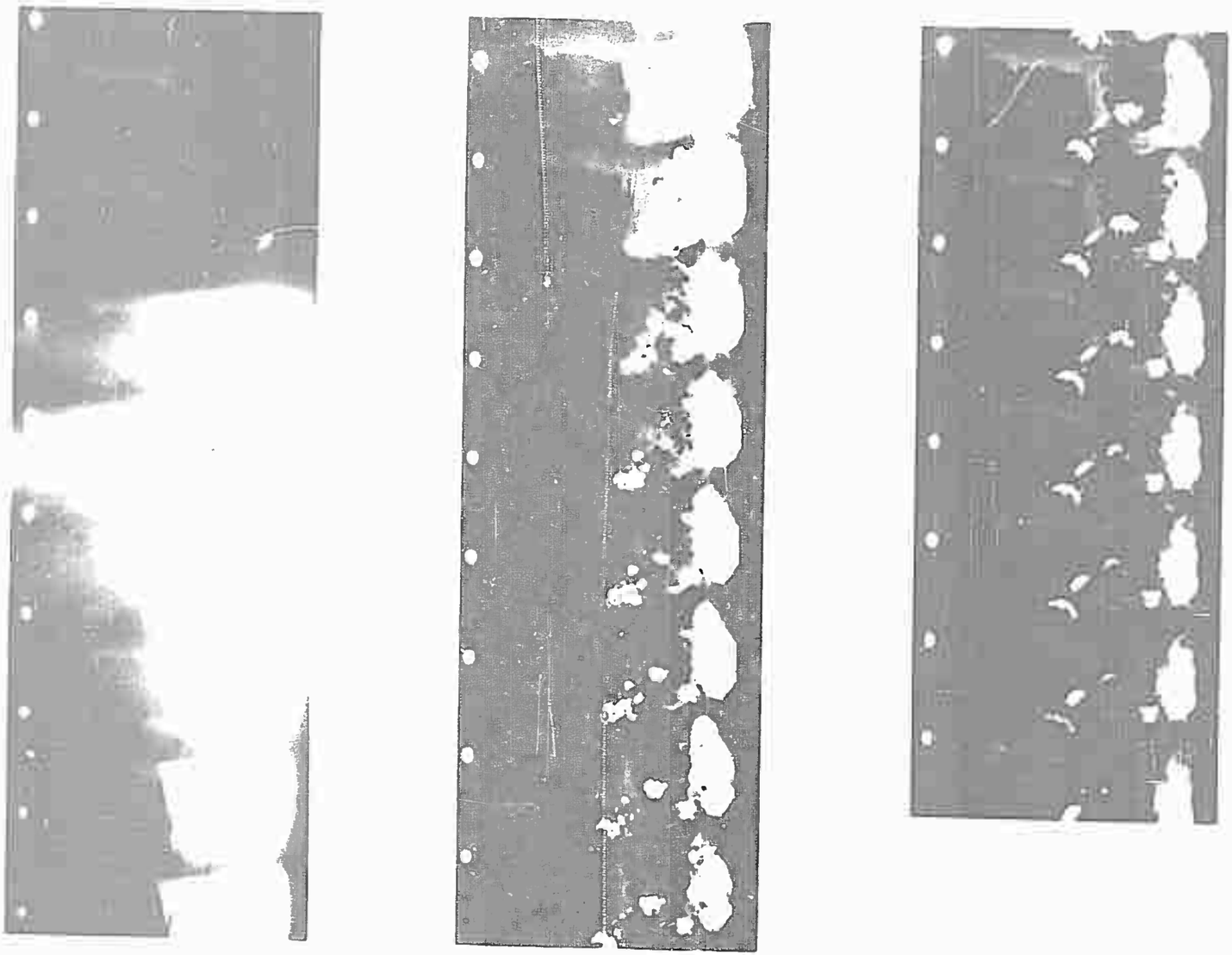
REVIEWED:
[signature]
J. K. WHALLON, Chief
Mathematics Section

APPROVED:
A. E. Karp
A. E. KARP, Chief
Analytical Laboratory

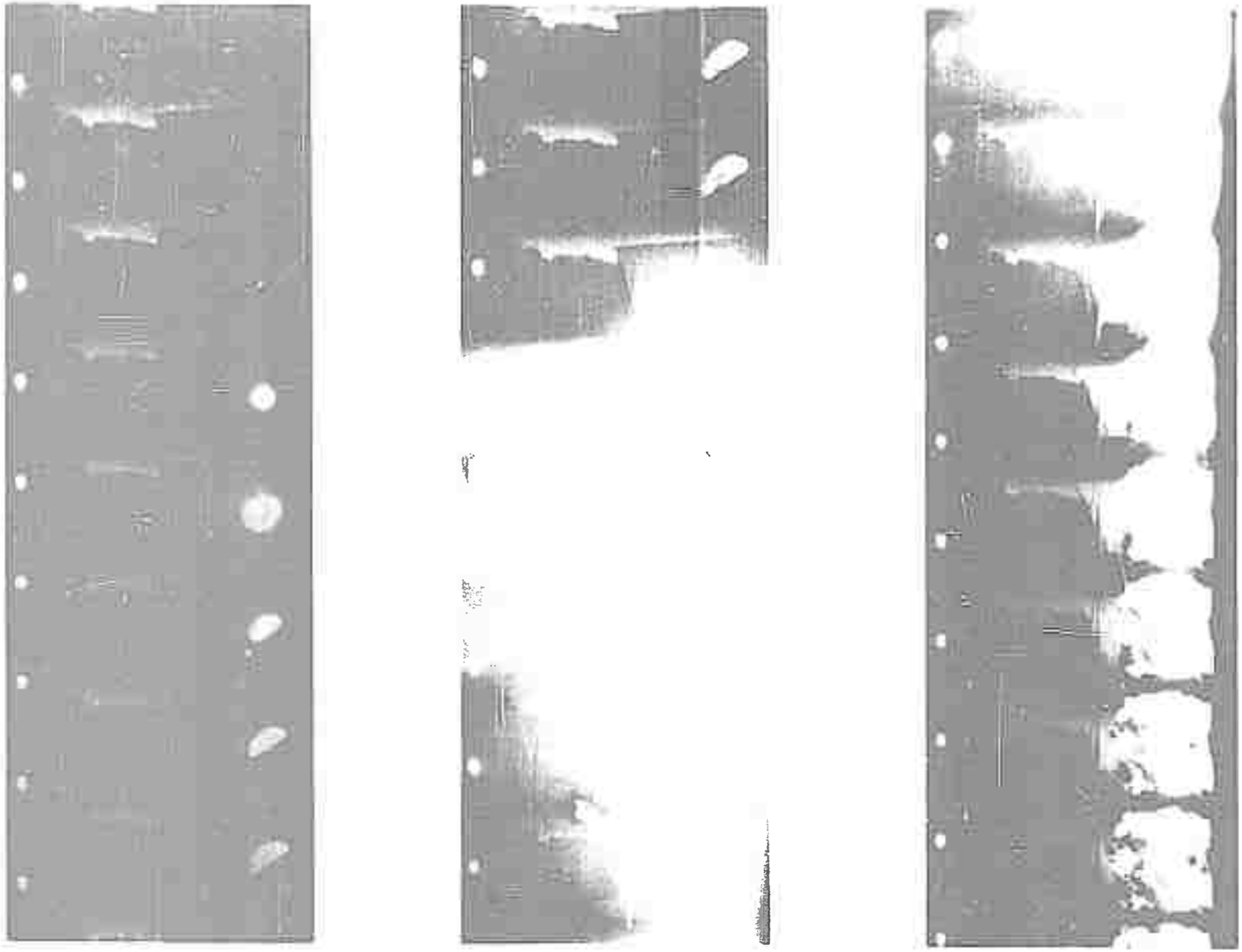
Engineering Laboratories
Supporting Services
Development & Proof Services
Aberdeen Proving Ground, Md.



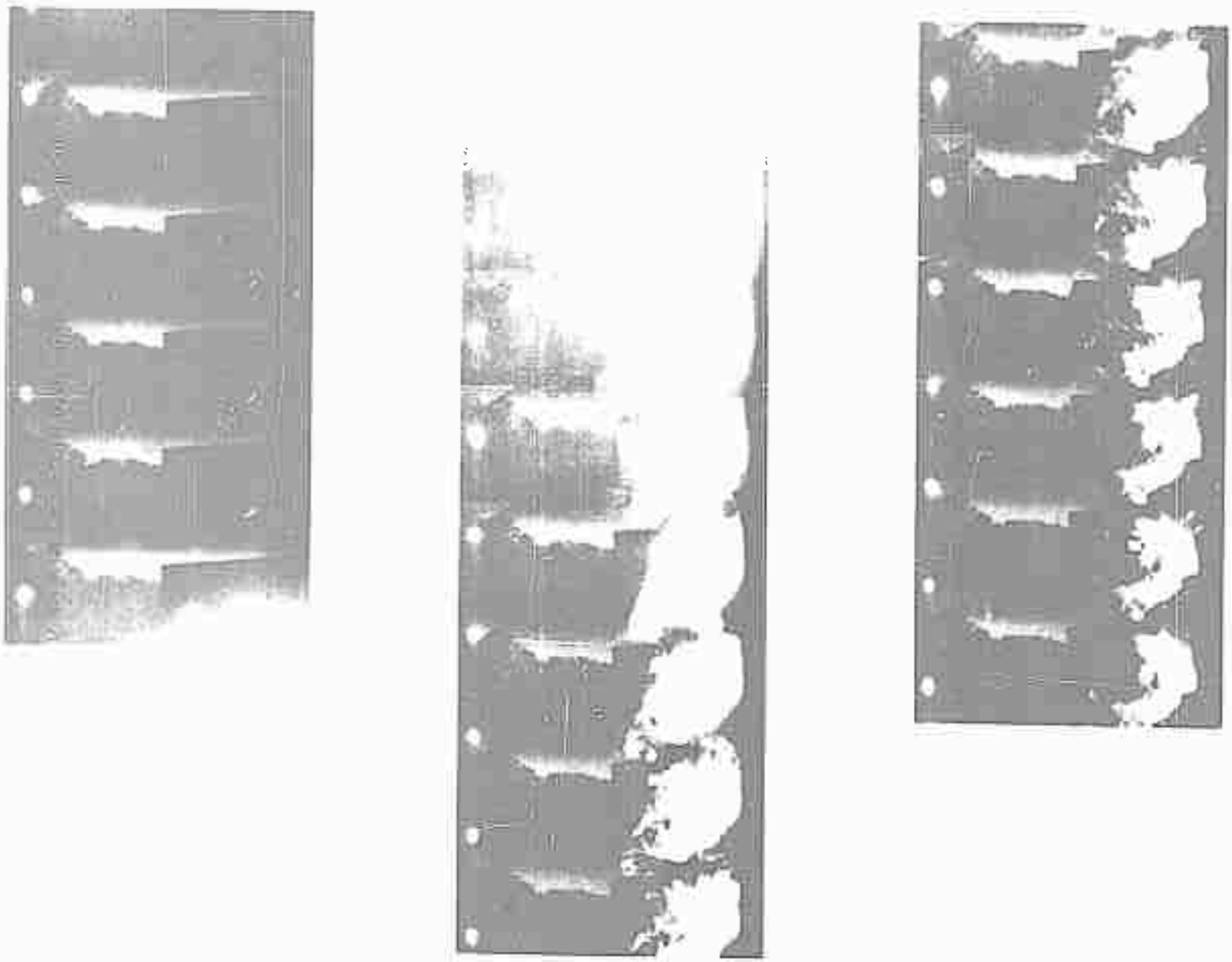
Test Round No. 1. Temperature of Ammunition -40°F.



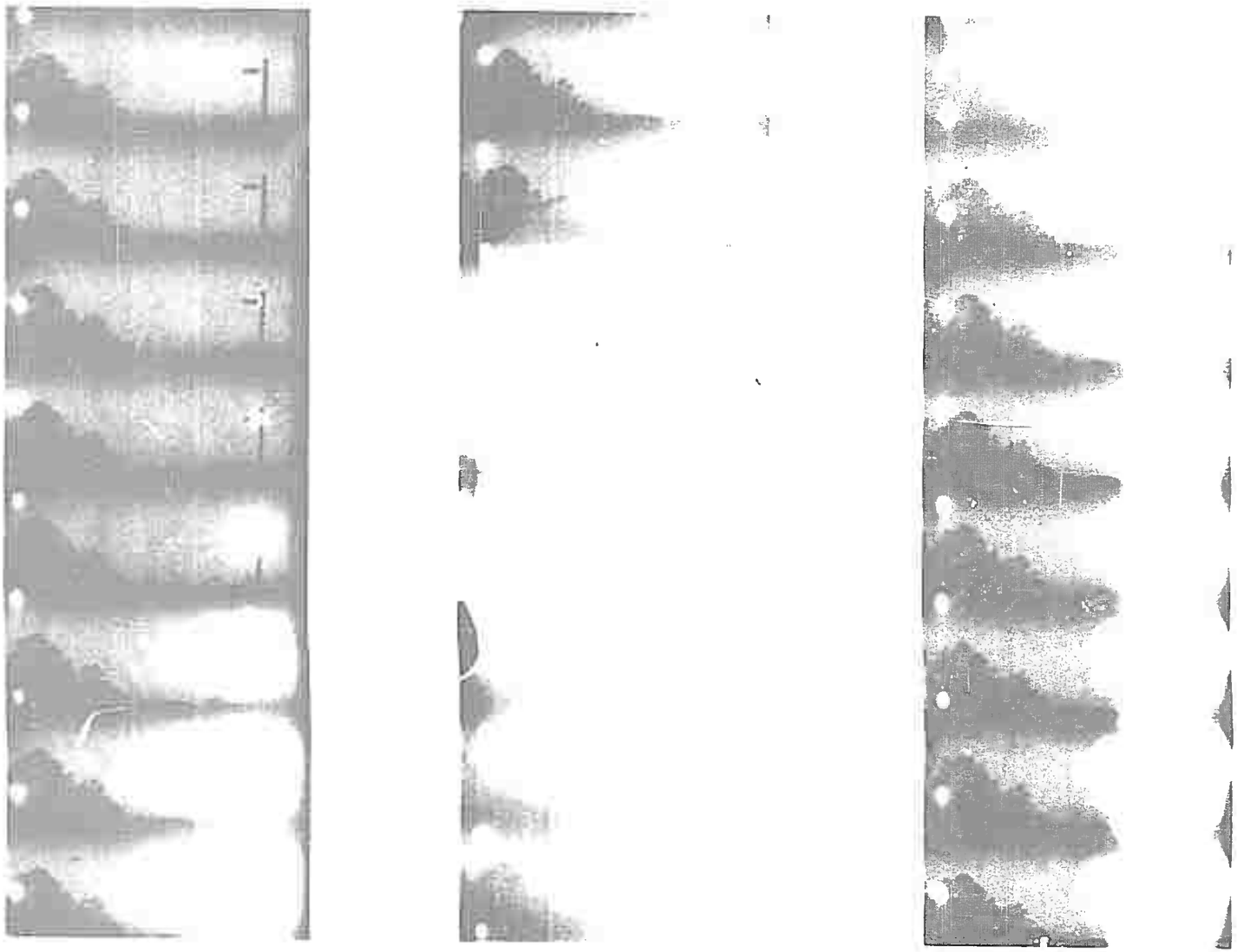
Test Round No. 3. Temperature of Ammunition -40°F.



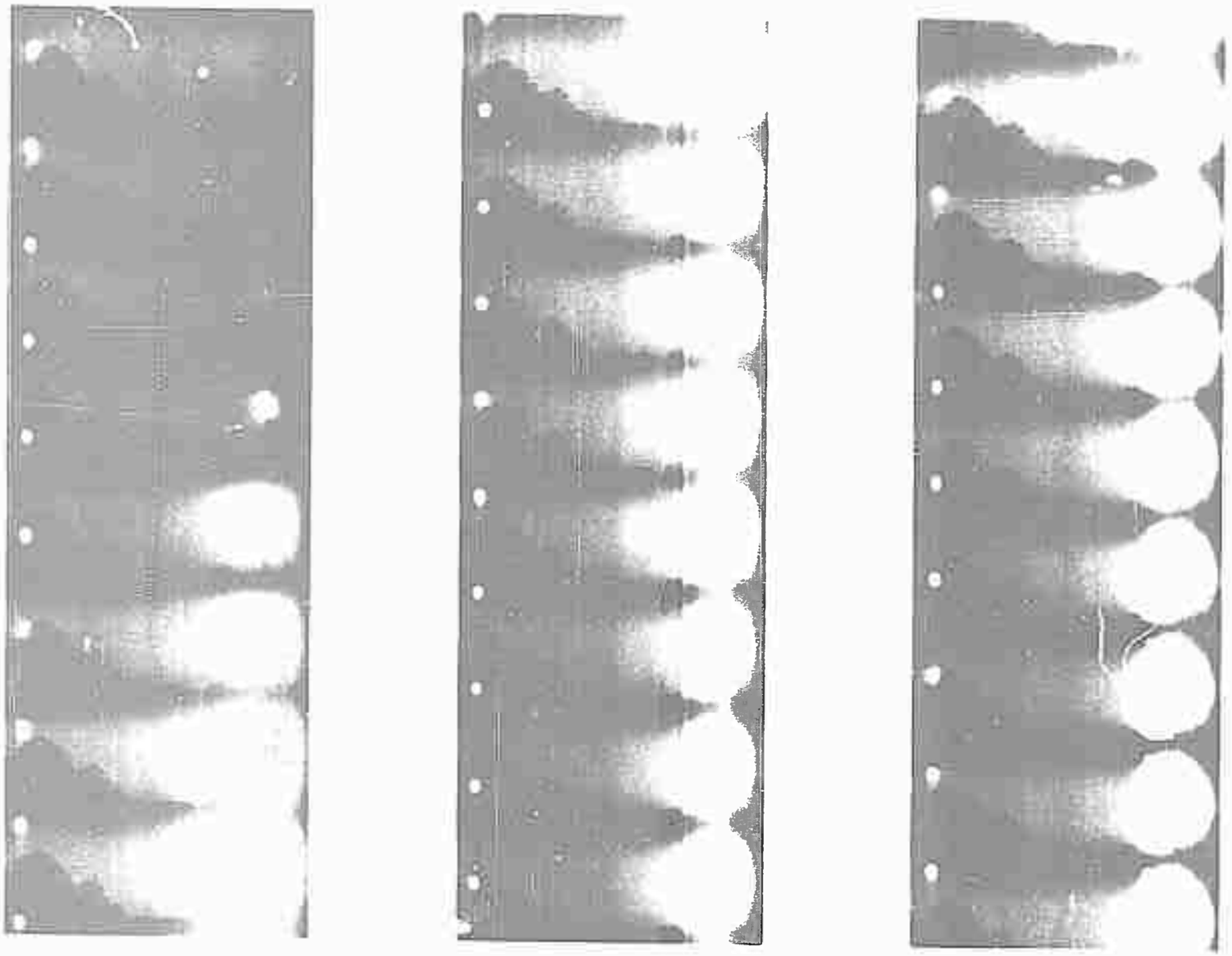
Test Round No. 4. Temperature of Ammunition -40°F.



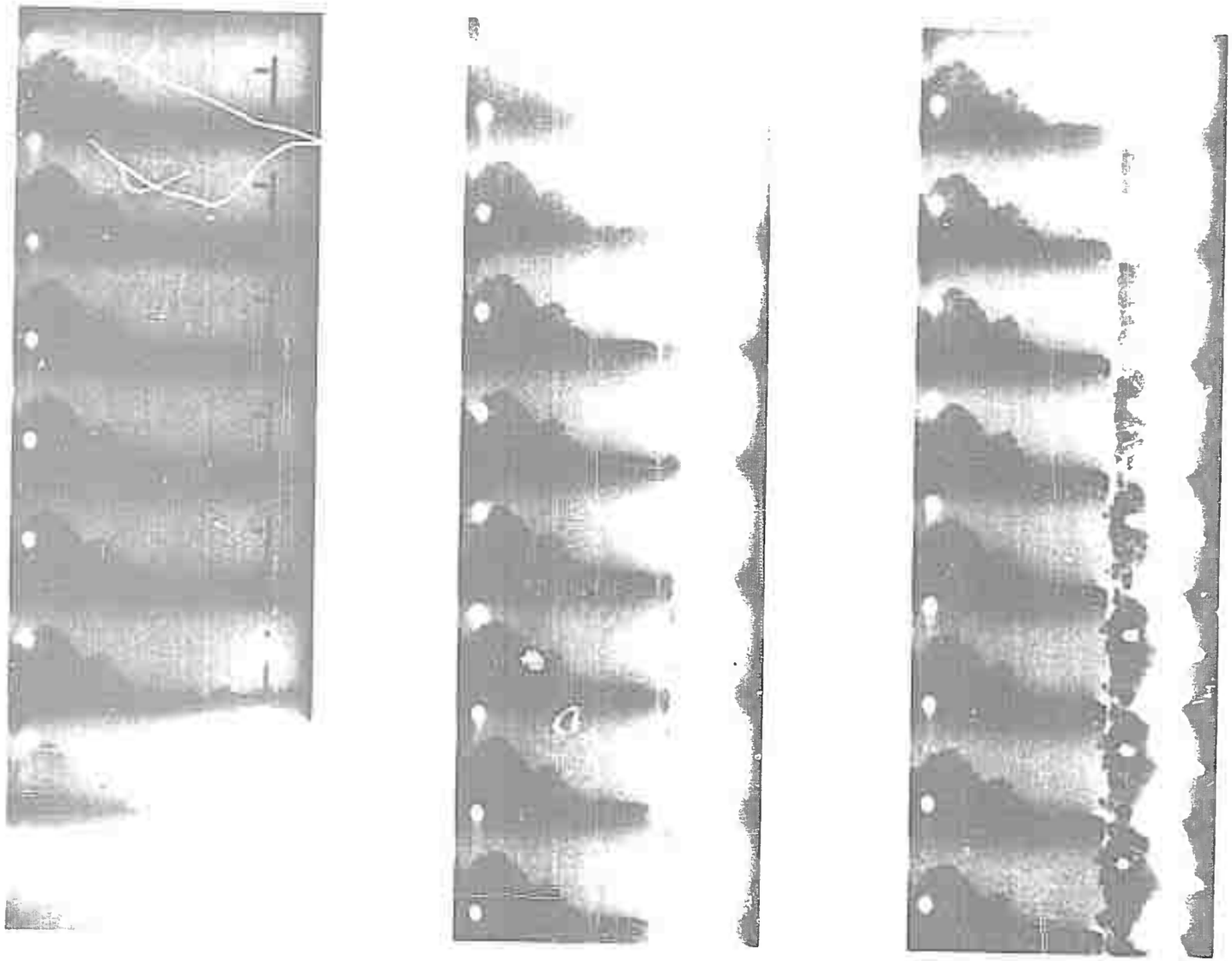
Test Round No. 5. Temperature of Ammunition -40°F.



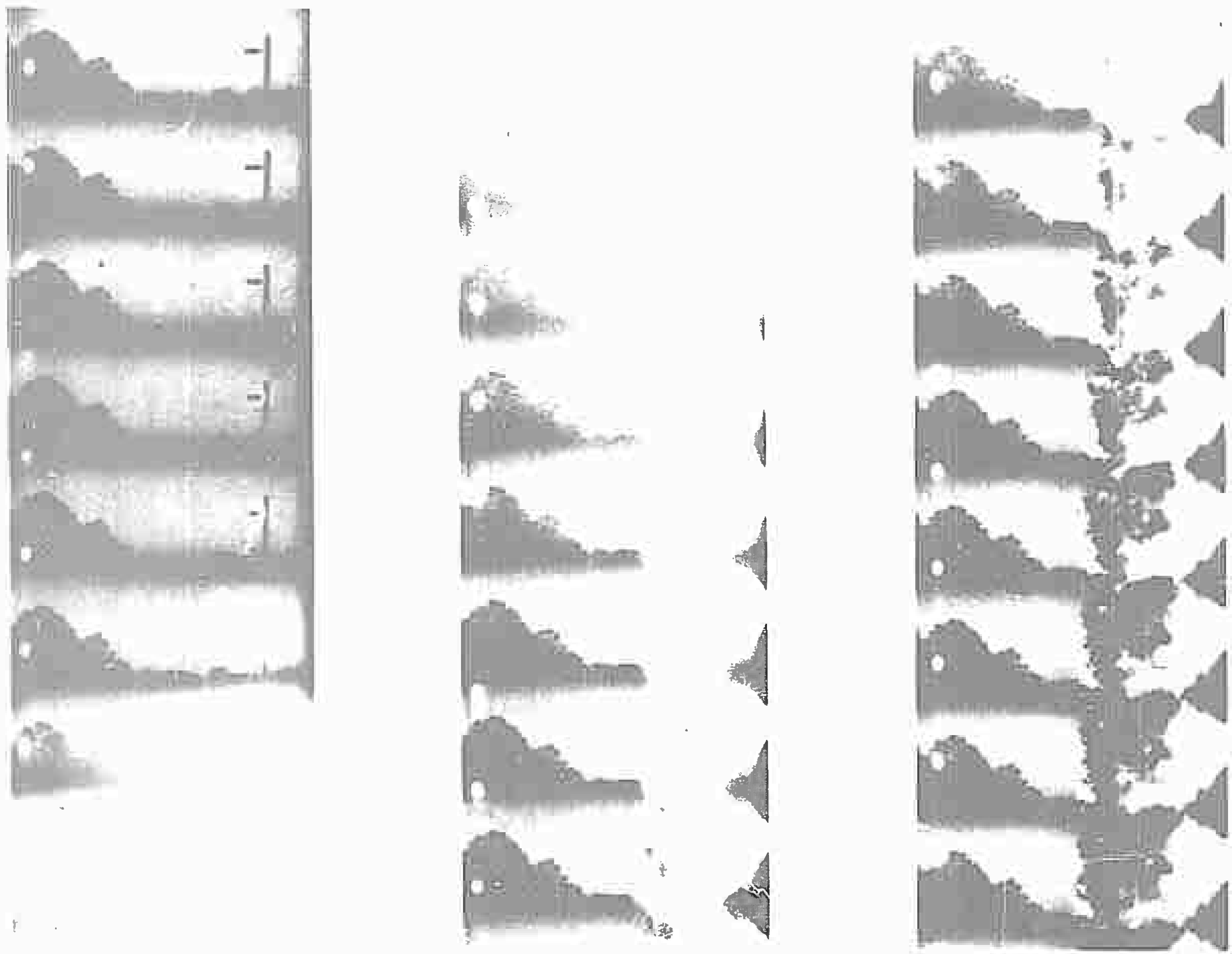
Test Round No. 6. Temperature of Ammunition $70^{\circ}F$.



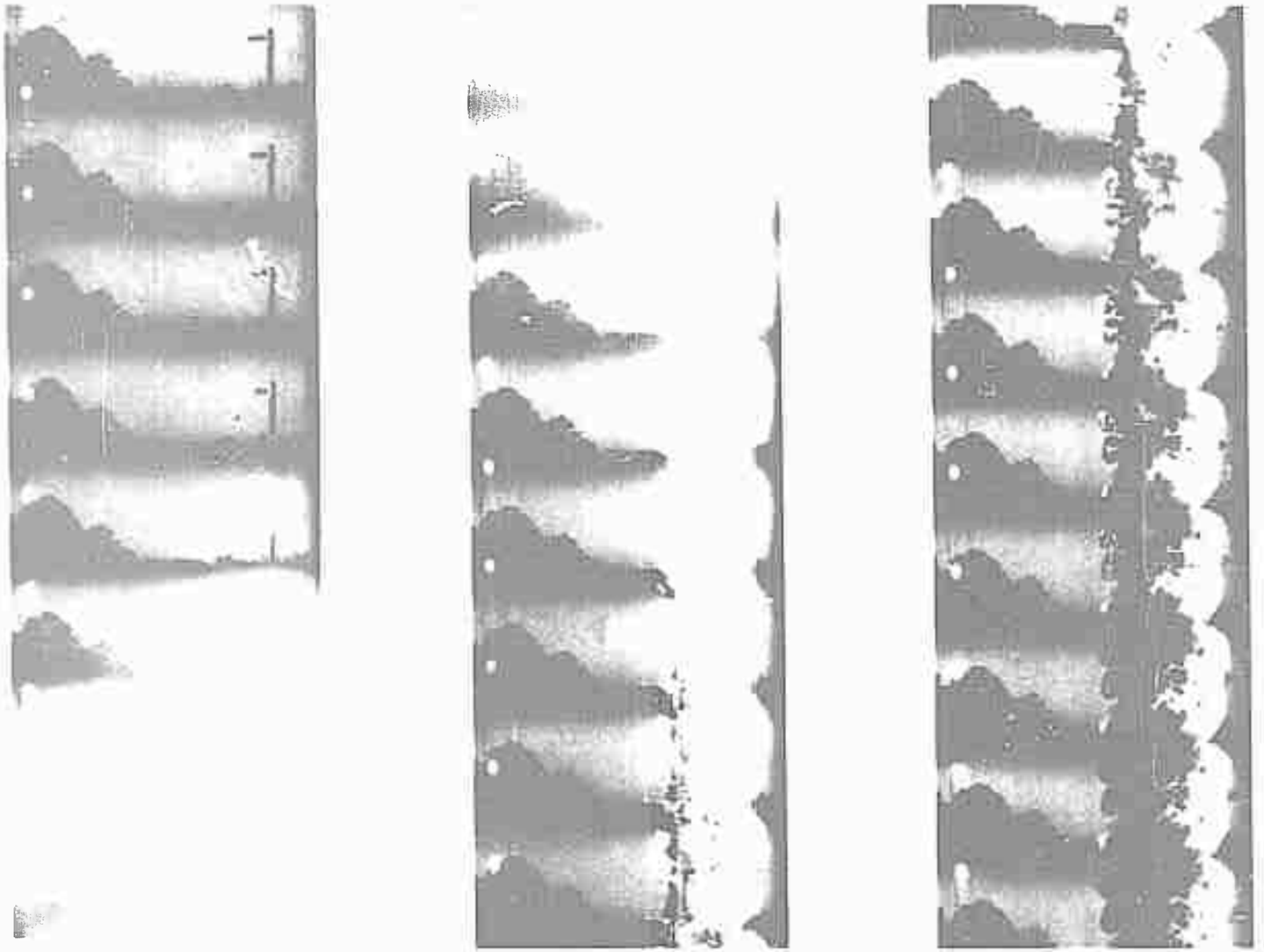
Test Round No. 7. Temperature of Ammunition /70°F.



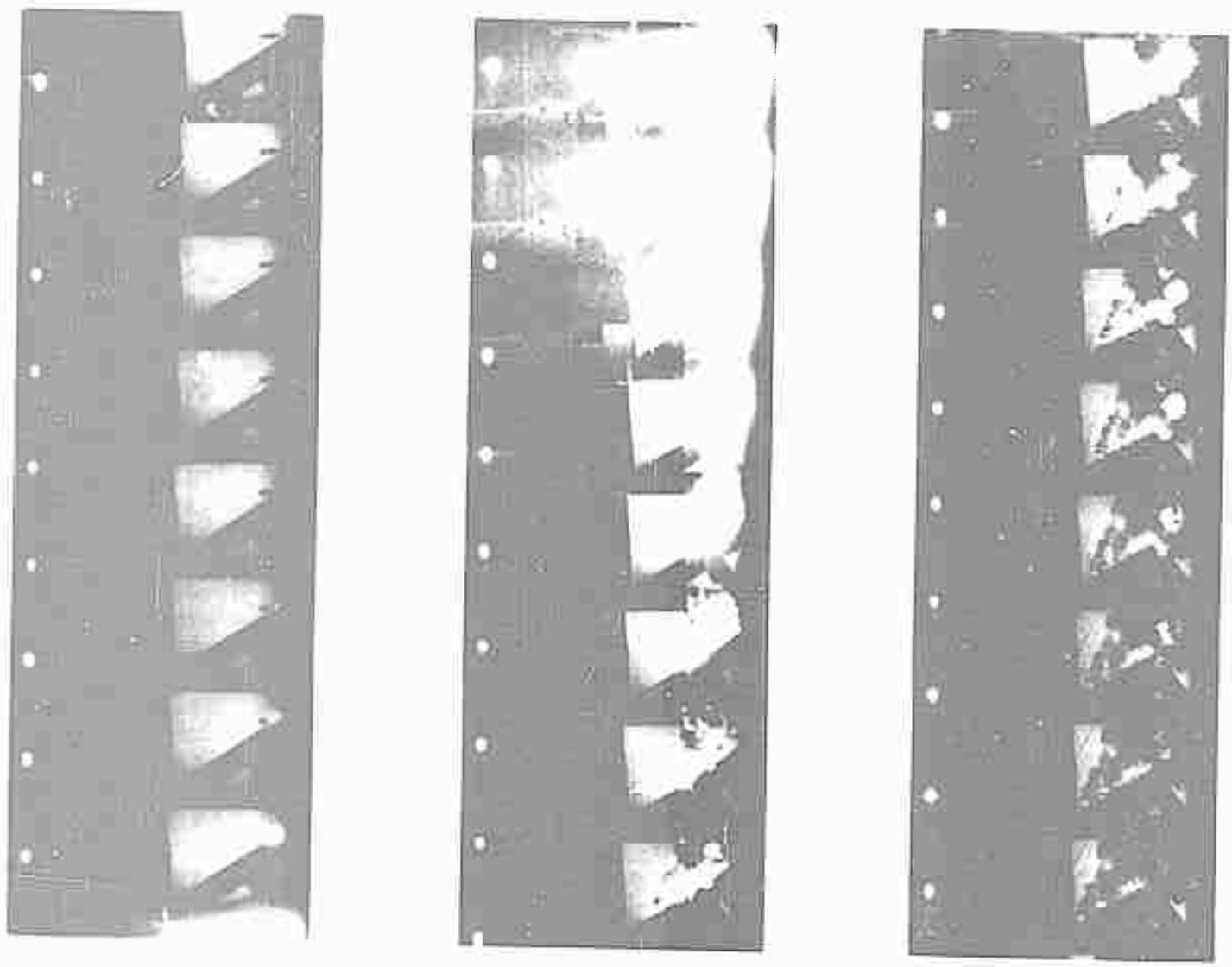
Test Round No. 8. Temperature of ammunition 70°F.



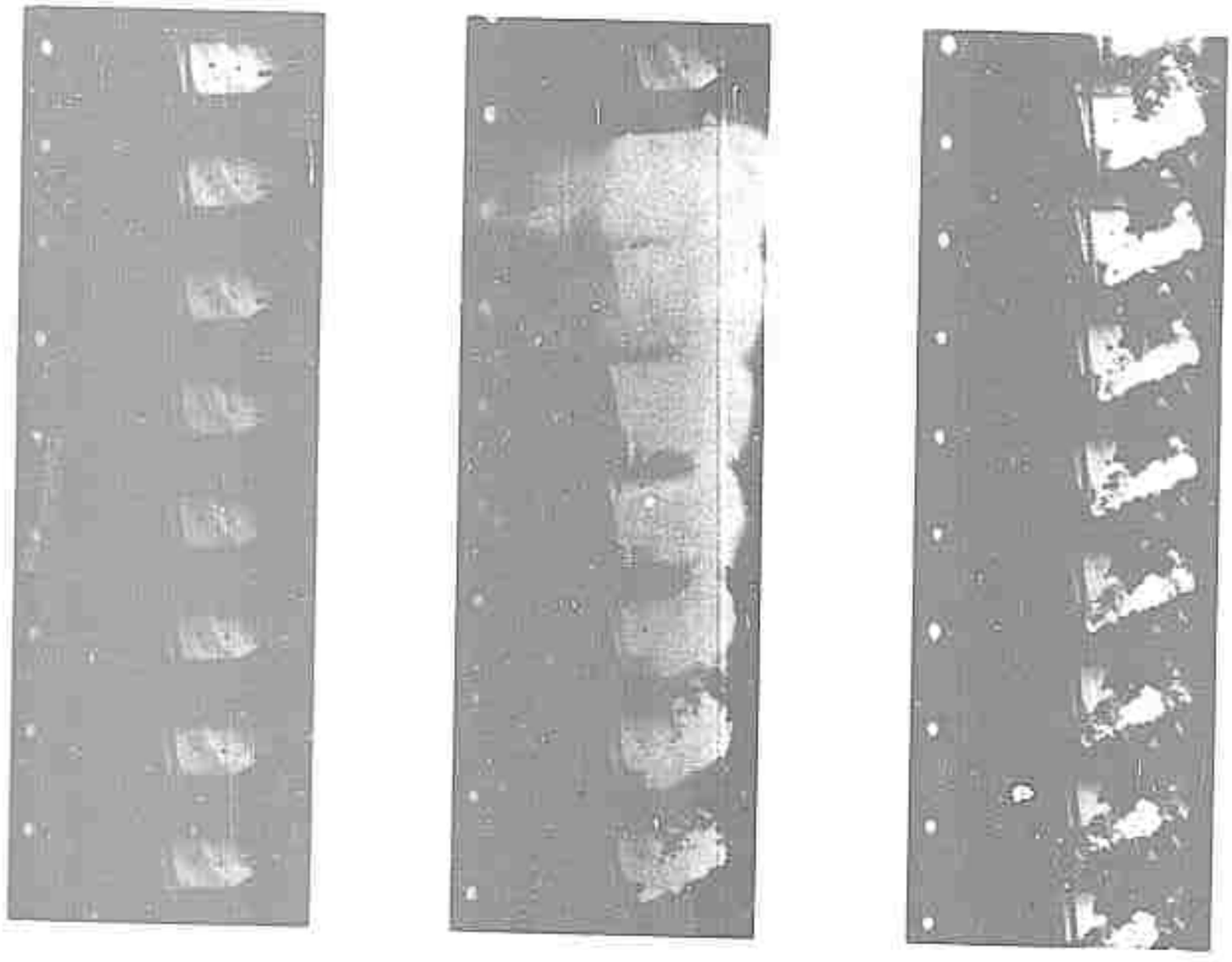
Test Round Nc. 9. Temperature of Ammunition $+70^{\circ}F$.



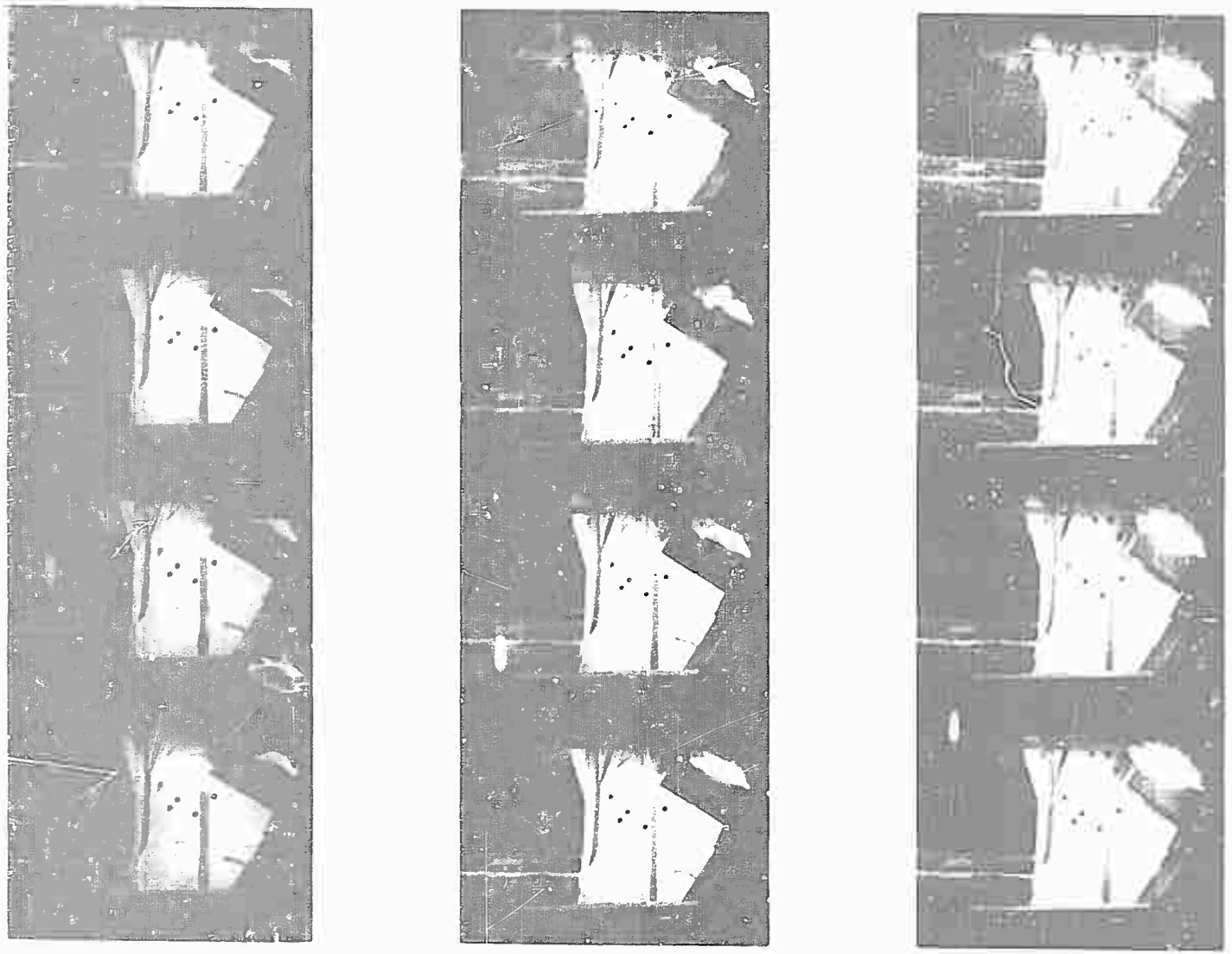
Test Round No.10. Temperature of Ammunition 70°F.



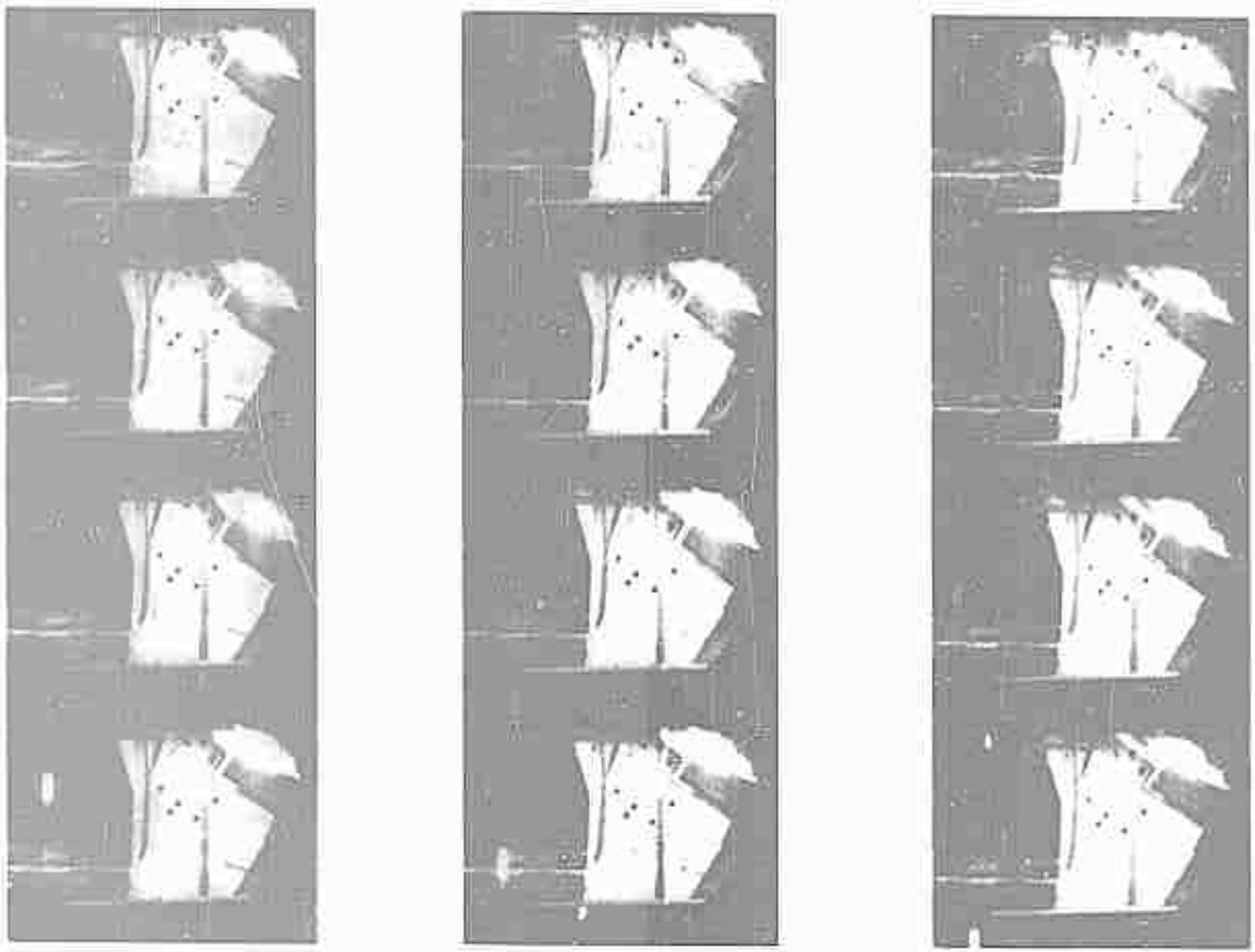
Test Round No. 11. Temperature of Ammunition +70°F.



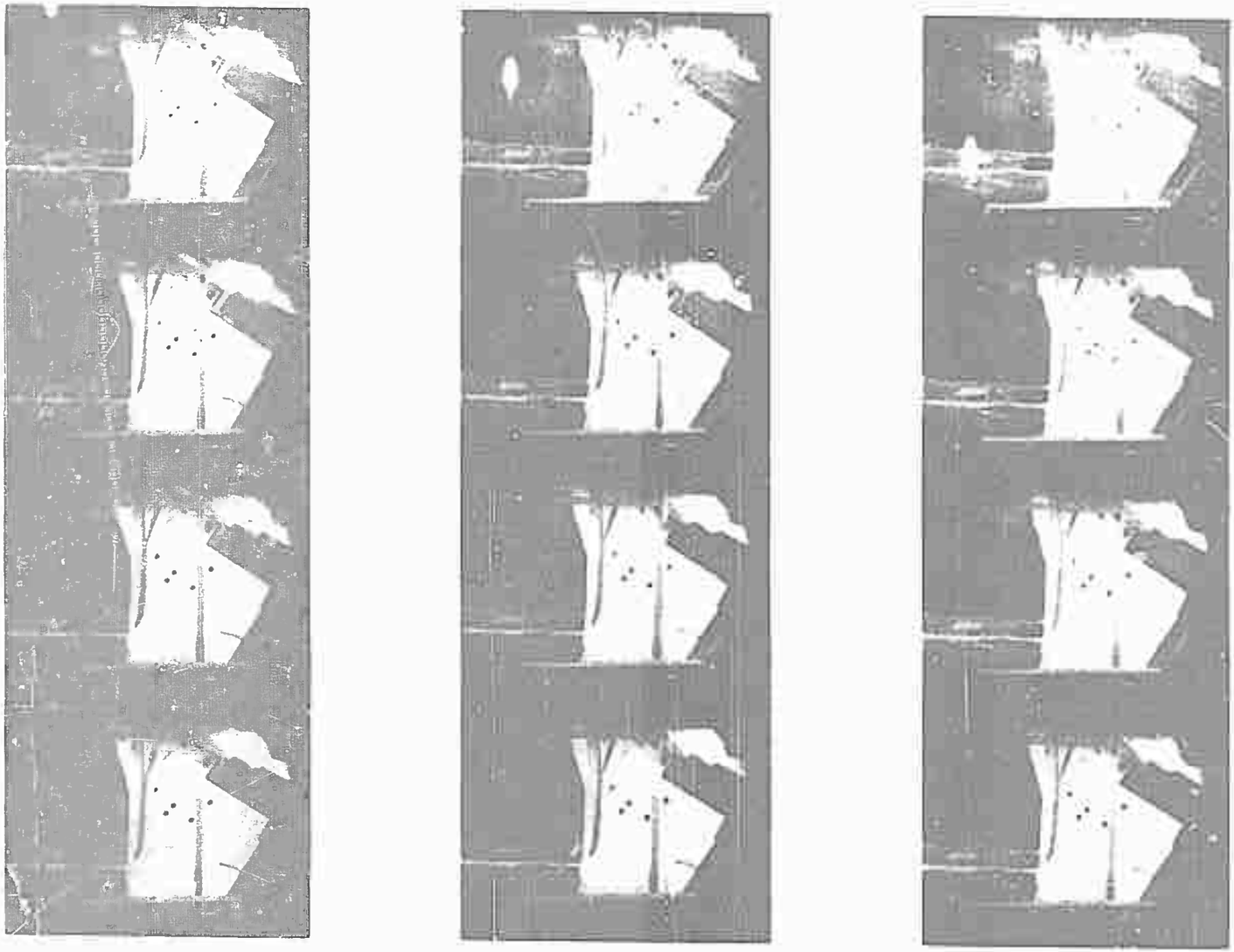
Test Round No. 12. Temperature of Ammunition /70°F.



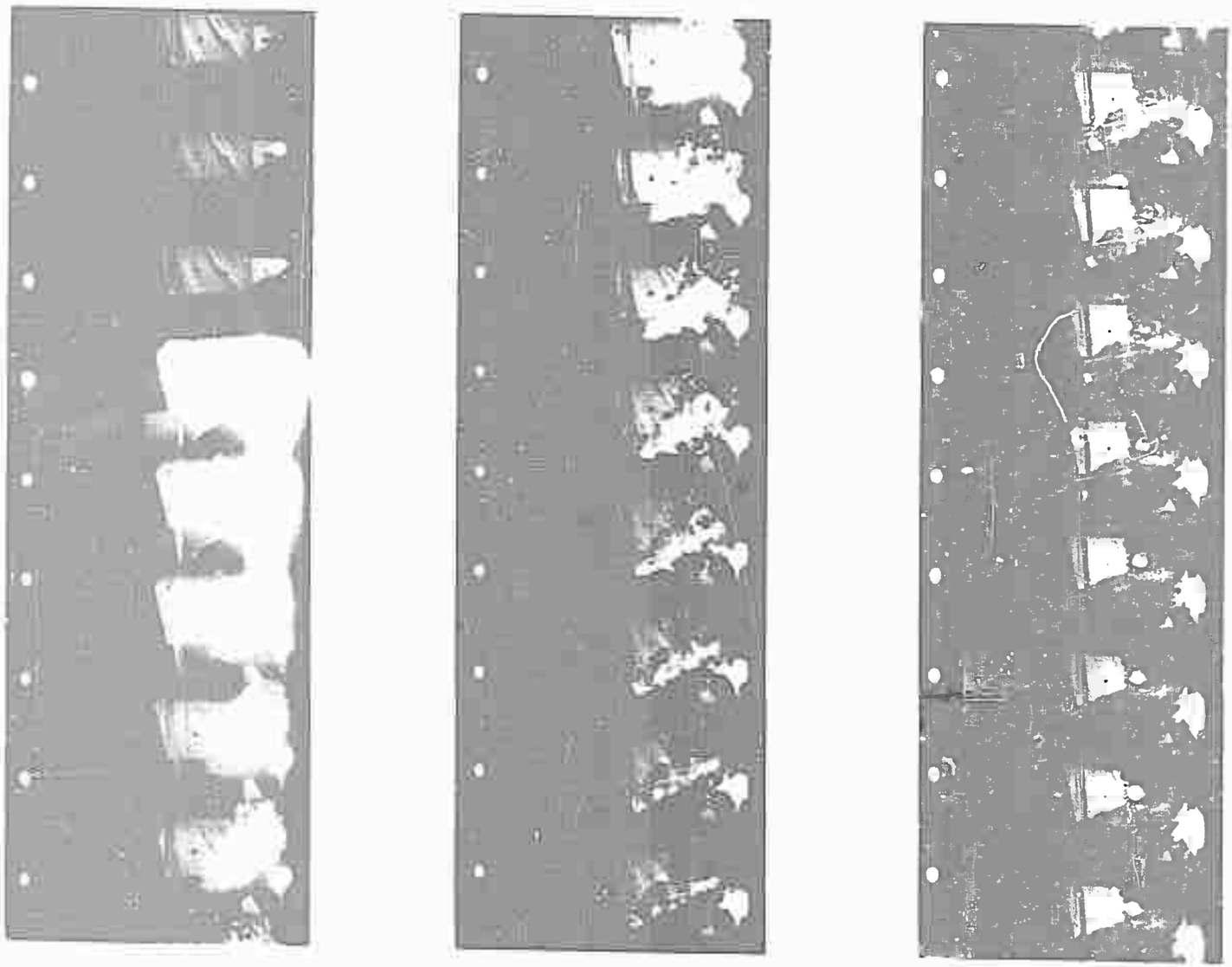
Test Round No. 13A. Temperature of Ammunition 170°F.



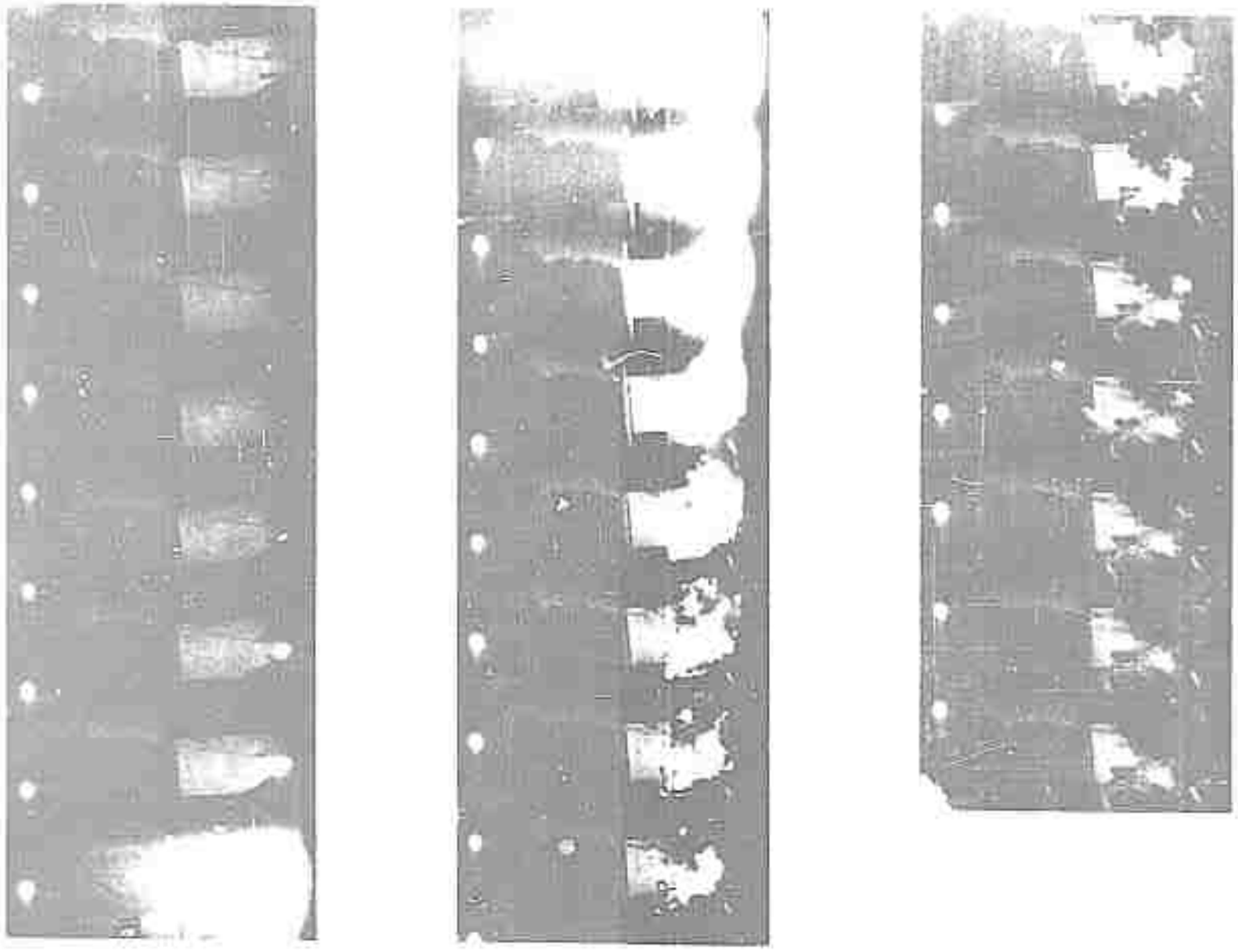
Test Round No. 13B. Temperature of Ammunition /70°F.



Test Round No. 13C. Temperature of Ammunition 170°F.



Test Round No. 14. Temperature of Ammunition /70°F.



Test Round No. 15. Temperature of Ammunition /70°F.

APPENDIX E

ARMY-P A DOVER, N.J. ORDDB-43 3-16-56 BOO 2278 Hopper- **EXPERIMENTAL AMMUNITION DATA CARD** NO 82304

T P R NO	KIND				AMM LOT NO.
SPEC NO	Shell, HEP, 75/25 Octol Loaded 90MM, T294E3 With Fuse Dummy, T199				PA-E-22942 QUANTITY IN LOT 15
DRG. NO None*	DRG. DATE OR REV.	ALLOT ADVICE	PROJECT NO. TA1-1461	RAD OR EPO NO	QUANTITY IN SHIPMENT
P. A. X. O. 829-009	PROP CHARGE	EXPECTED M. V	EXPECTED PRESSURE	ASSEMBLED BY PA	DATE OF ASSEMBLY June, 1956

REMARKS: Packed: Improvised. 1 Shell/fiber container; 2 fiber containers/wood box. Shell were melted - loaded in two pours. Pouring temp. was 95 - 98°C. After first pour shell was vibrated for about 2 minutes to dislodge air bubbles from molten charge. Risers were kept molten for 1/2 hour with steam-heated probe. Fuze cavity 1.260 ± .020" dia, 1.340 ± .020" deep (measured from rear end of shell body) drilled in cast charge. See back of card for weights of shell felt disc, etc. (Over)

COMPONENT	Metal Parts	75/25 Octol	Fuze				
KIND	Assly Shell HEP	Bursting Charge	Dummy T199				
	T294E3						
DRG. NO.	J7527-B&M		unk				
DRG. DATE OR REV.	5-8-56		unk				
INSP'D BY	Chamberlain	PA	unk				
DATE	1956	1956	unk				
LOT NO	YGC-1460	Batch #34	unk				

PREPARED BY D. Spoble, Loading Br., Ind. DIVISION

CERTIFIED TO BY E. Champion INSPECTOR, Inspection DIVISION

PICATINNY ARSENAL DOVER, NEW JERSEY

Card No. 82304

Shell #	Wt. Body Empty	Wt. Body Loaded	Wt. HE Charge	Wt. Assembly w/Dummy Fuze
1	3.10 lb.	6.42 lb.	3.32 lb.	7.12 lb.
2	3.14	6.46	3.32	7.15
3	3.10	6.42	3.32	7.12
4	3.07	6.39	3.32	7.09
5	3.12	6.44	3.32	7.14
6	3.15	6.48	3.33	7.17
7	3.07	6.38	3.31	7.08
8	3.01	6.32	3.31	7.02
9	3.09	6.41	3.32	7.11
10	3.07	6.39	3.32	7.08
11	3.12	6.44	3.32	7.14
12	3.14	6.46	3.32	7.16
13	3.09	6.41	3.32	7.11
14	3.02	6.36	3.34	7.06
15	3.09	6.41	3.32	7.10

Felt Disc 1.25 - .01" dia by 0.25 ± .03 thick assembled forward of Dummy Fuze in Fuze Cavity in Bursting Charge. *Loaded and assembled in accordance with Tech. J.O. 829-009-233 D. 5-2-56.